Sub-arcsecond localization for the Constellation-X HXT

David M. Smith, U. C. Santa Cruz
Gordon J. Hurford, U. C. Berkeley
Michael Pivovaroff, U. C. Berkeley & LBNL

Why arcsecond localization?

Localization of AGN/ULX sources within galaxies
Identification of double AGN
Localization of binaries within globular clusters
Localization of unidentified EGRET sources
Position of pulsars within SNR
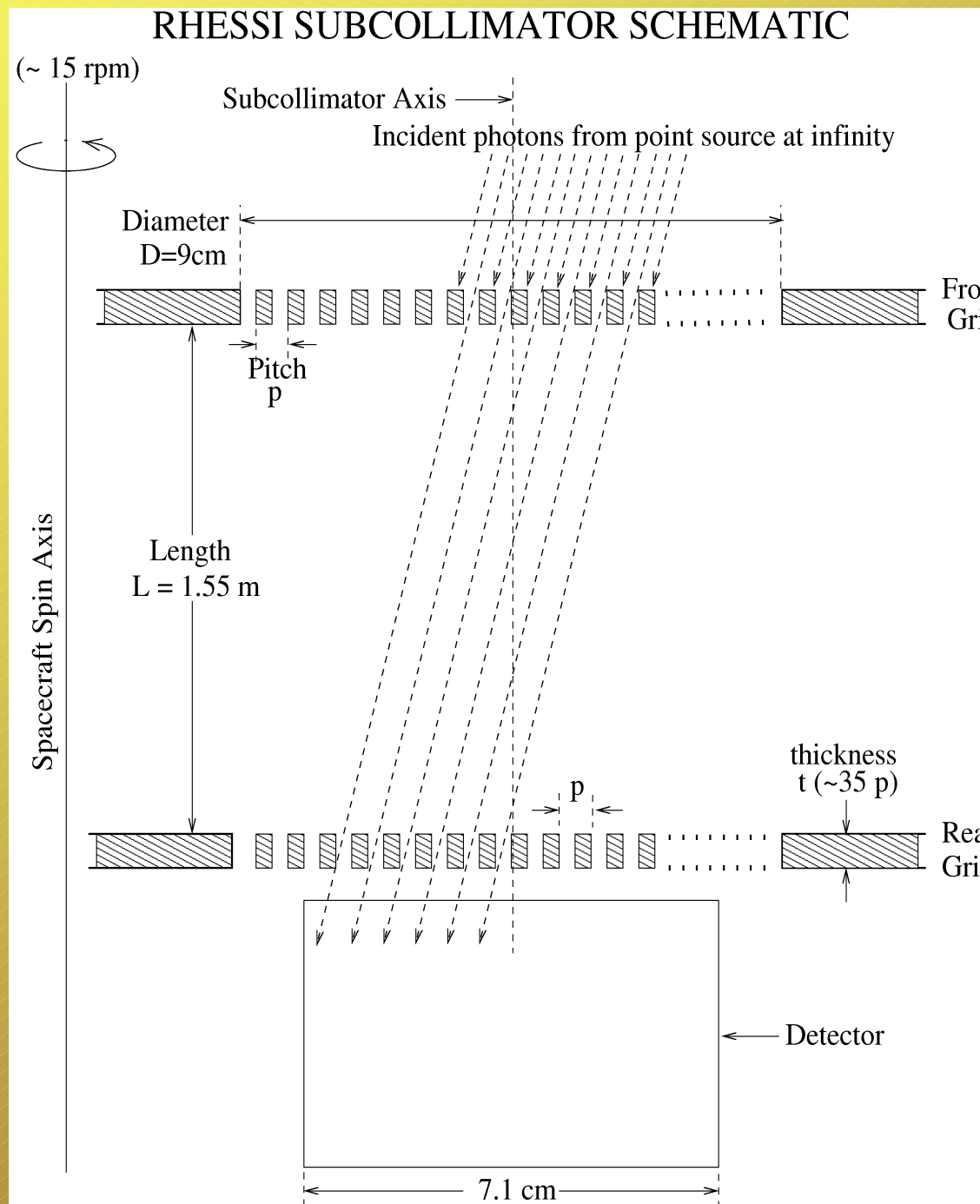Counterpart identification for highly obscured sources:
    "hidden" AGN
    INTEGRAL obscured Galactic binaries

The latter points to the HXT as the preferred instrument

The RMC principle

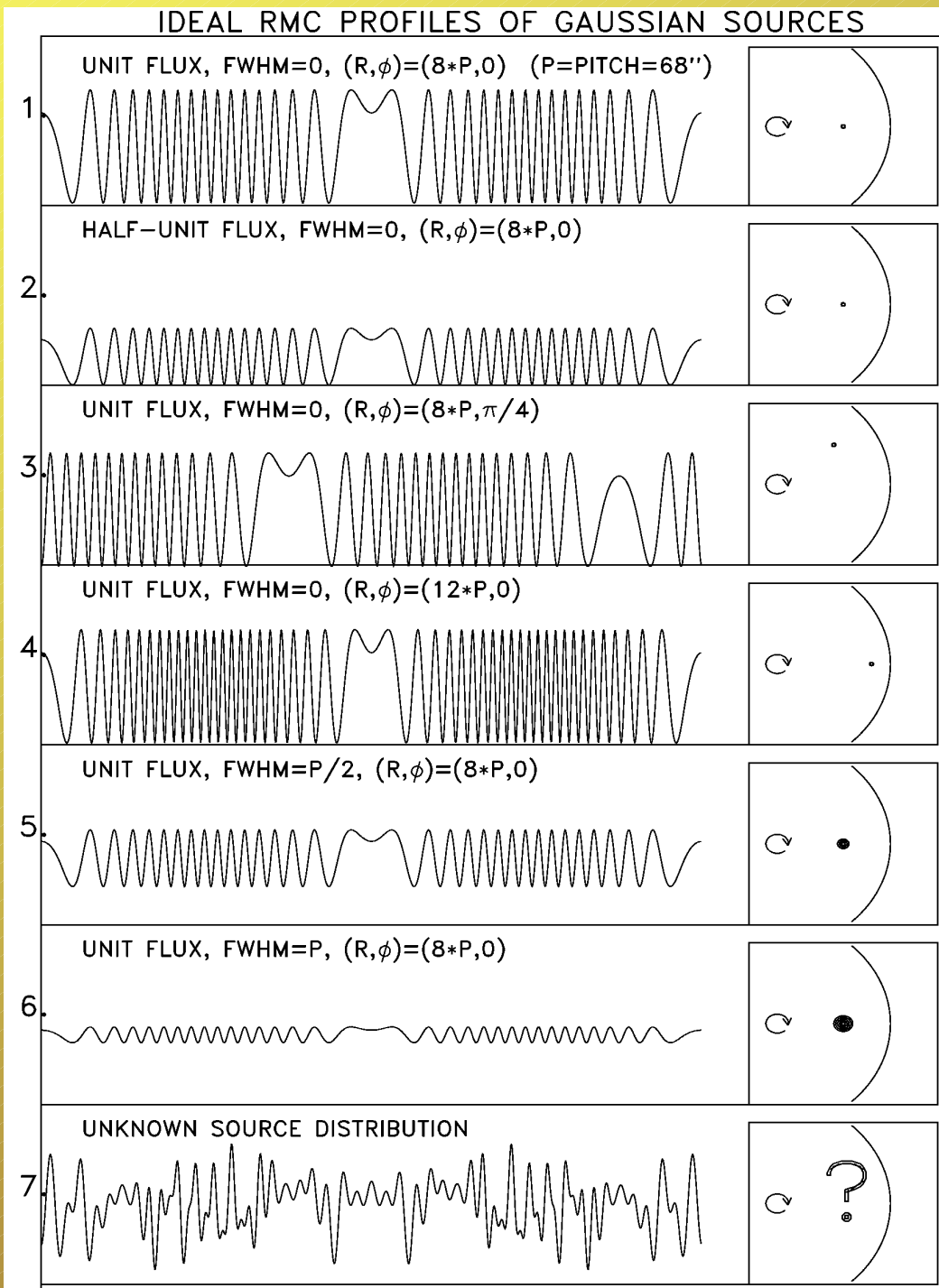[Oda 1965;
Schnopper et al. 1968]

RHESSI SUBCOLLIMATOR SCHEMATIC

(~ 15 rpm)

Subcollimator Axis →

Incident photons from point source at infinity

Diameter
D=9cm

Fro...
Gr...

Pitch
p

Spacecraft Spin Axis

Length
L = 1.55 m

thickness
t (~35 p)

p

Rea...
Gri...

Detector

7.1 cm

Phase <-> Azimuth

Frequency <-> radius

Fractional amplitude
  <-> size relative to
     grid resolution

Inverse problem is
formally identical to
radio interferometry

Figure by G. J. Hurford

IDEAL RMC PROFILES OF GAUSSIAN SOURCES

1. UNIT FLUX, FWHM=0, (R,φ)=(8*P,0) (P=PITCH=68'')

2. HALF-UNIT FLUX, FWHM=0, (R,φ)=(8*P,0)

3. UNIT FLUX, FWHM=0, (R,φ)=(8*P,π/4)

4. UNIT FLUX, FWHM=0, (R,φ)=(12*P,0)

5. UNIT FLUX, FWHM=P/2, (R,φ)=(8*P,0)

6. UNIT FLUX, FWHM=P, (R,φ)=(8*P,0)
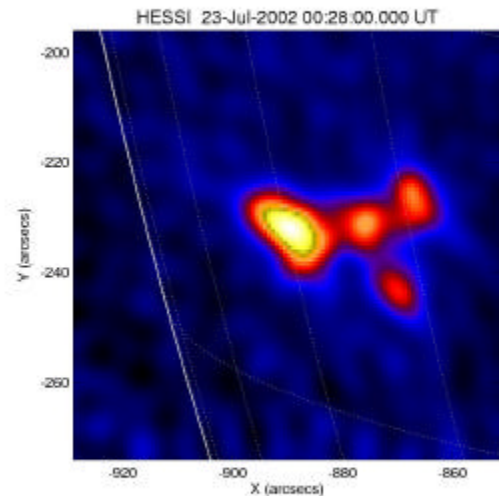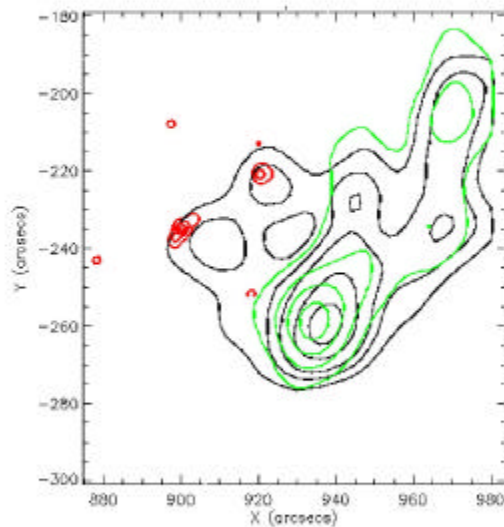
7. UNKNOWN SOURCE DISTRIBUTION

RHESSI imaging performance:

Down to 2.3 arcsec FWHM, 1.55m grid separation

9 grid pitches give simultaneous imaging of diffuse and pointlike sources

300 counts allow
localization to
1/6 of grid resolution
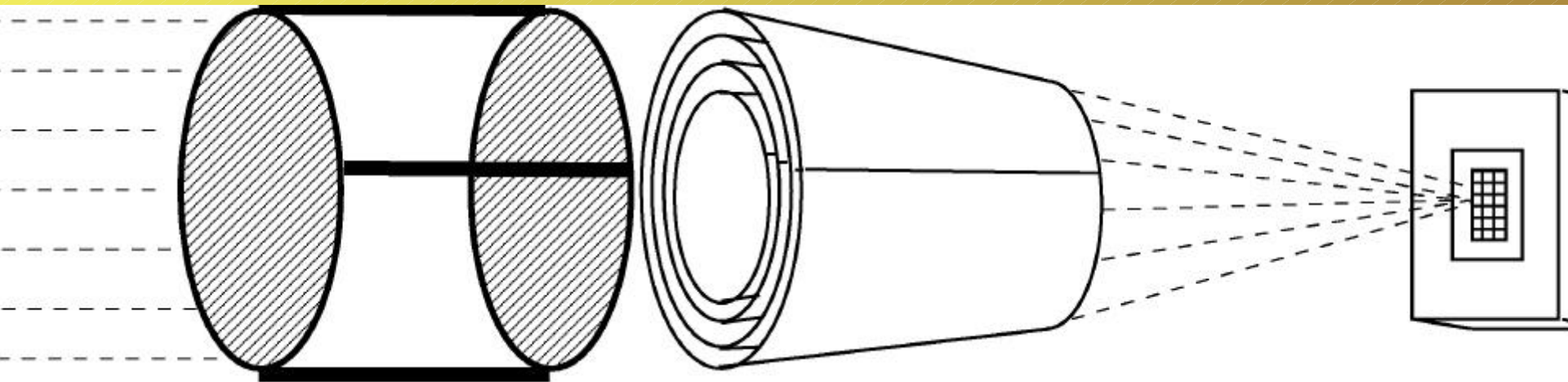
See Hurford et al. 2002,
in Solar Physics

Figures by S. Krucker

Gorenstein & Finoguenov (1994, SPIE 2280, 11)
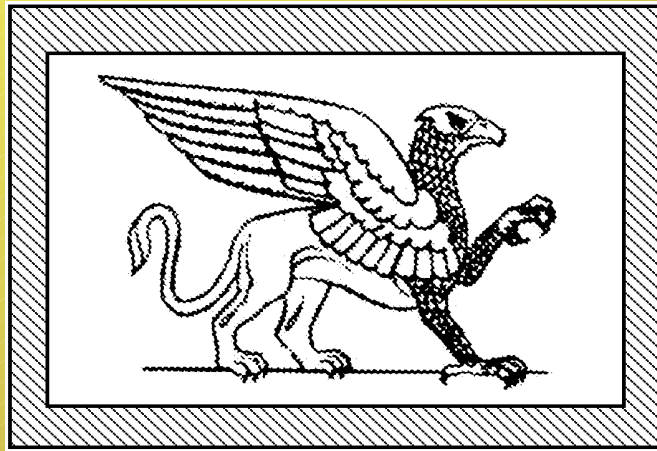suggested placing an RMC above focusing optics

Higher resolution than optics alone

Lower background than grids alone

griffin, n.

: a mythical animal typically having the head, forepart and wings of an eagle and the body, hind legs, and tail of a lion.   Merriam-Webster, 11th Collegiate Edition

GRIFFIN   = GRIds Followed by FocusINg

TWO CHOICES:

"Full" optics (quasi-Wolter I):
  Best separation of sources in wide field;
  Best background reduction
  75% loss of source flux
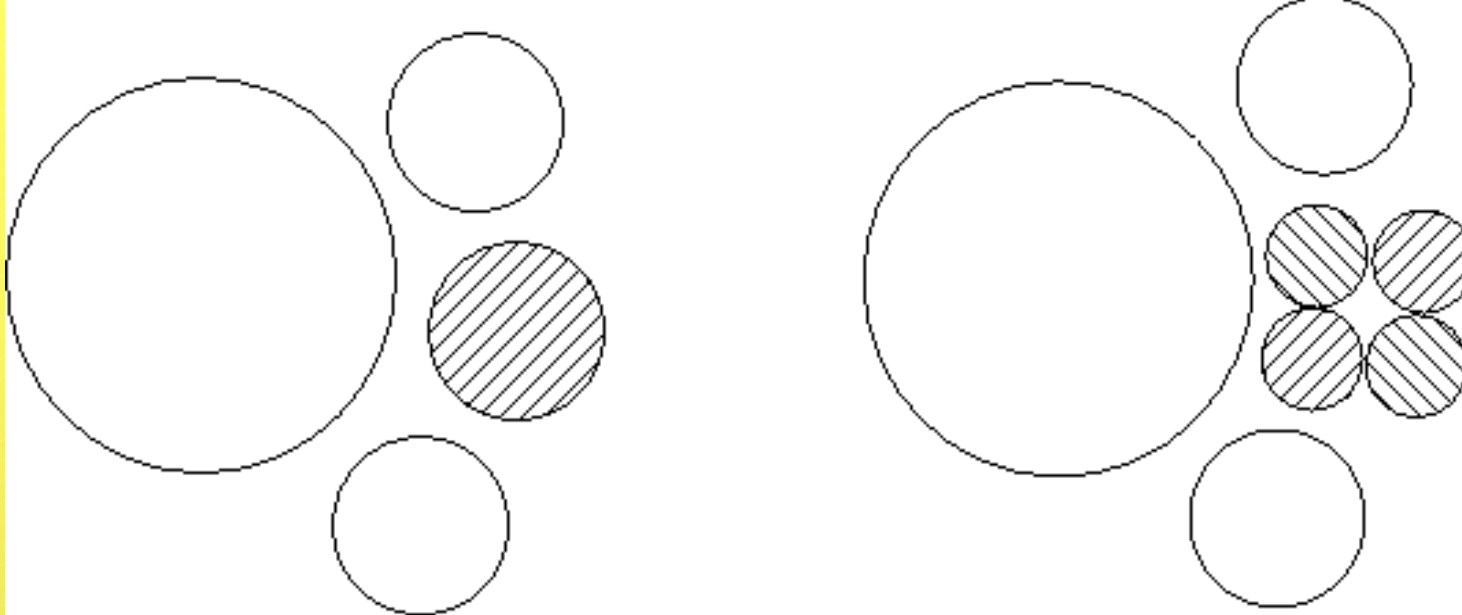
Simple conical optics:
  On-axis source images to a point
  Off-axis sources image to rings
  Still good background reduction
  Single reflection makes up for some of
    signal loss from grids

Two-reflection:
   25% total loss of area
   Slight mass increase

One-reflection:
   Little loss of area
   Little net mass change in
      optics (less glass or Ni)
   3 extra detectors

Requirements for GRIFFIN on Con-X:

REQUIRED:

Aspect knowledge to ~ 0.5"

Excellent twist alignment of grids

GRID PARAMETERS:

Finest RHESSI pitch: 34 microns
1-meter separation gives 3.5"
FWHM, 0.6" localization

NOT REQUIRED:

Arcsec pointing stability

Rotation of spacecraft

Rotation of grids (if there is suitable pointing jitter)

Precise linear aligment of grids